

Health benefit of flaxseed (*Linum usitatissimum*): a mini review

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Abstract

The importance of nutrition and its impact on human well-being has increased interest in "functional foods." This has prompted a reevaluation of the practical advantages offered by various conventional food sources. It is the richest known source of alpha-linolenic acid (ALA), phytoestrogen lignans, and solubility fiber, flax continues to acquire popularity as a functional food and is currently gaining attention in the field of cardiovascular disease. Secoisolariciresinol diglucoside, a lignin derivative found in flaxseeds, is metabolized into mammalian lignans. Lignans have numerous biological effects. Flax lignans have an effect on the early warning indications of breast and colon carcinogenesis in animal models. Regular flaxseed consumption may affect total and low-density lipoprotein levels in the blood. Increase serum levels of the omega-3 fatty acids ALA and eicosapentaenoic acid, reduce inflammatory markers, and reduce postprandial glucose absorption. Flaxseed has demonstrated significant antioxidant and anti-inflammatory properties in both animal and human research. In cases such as cardiovascular risk, certain types of cancer, and other metabolic disorders, a flaxseed supplement in the diet may be beneficial. Numerous studies have demonstrated the benefits of fresh flaxseed and flaxseed-based baked goods for maintaining health and preventing disease. This article focuses on the 'nutraceutical' potential of 'flaxseed' and its function as a 'medicine food' that is both therapeutic and preventative.

1. Introduction

Due to the prevalence of various degenerative lifestyle disorders, maintaining a healthy lifestyle in the modern world is challenging (Khalid *et al.*, 2022). Due to the swiftly evolving global health scenario and the rapid realization of the negative effects of unregulated food processing and overmedication, plant-based products have received well-deserved attention (Noreen *et al.*, 2021). The growing interest in foods that can act as medications is a consequence of a greater understanding of the significance of diet and the pursuit of health. 'Functional foods' or 'nutraceuticals' are foods or dietary supplements that may provide health benefits beyond simply meeting nutritional requirements. Beyond what would be expected based on their nutritional value, functional foods improve health (Naik *et al.*, 2018; Tufail *et al.*, 2021). Numerous ancient foods with beneficial properties are being discovered, and healthy ingredients are being added to new food products.

Flaxseed is gaining recognition as a functional diet because it is rich in phytochemicals, alpha-linolenic acid, an essential omega-3 fatty acid, and other nutrients (Noreen *et al.*, 2020). In addition to providing energy and dietary fiber (flax precursor), flaxseed was selected as one of six nutraceuticals (Seralthan and Baskaran, 2020; Shaikh *et al.*, 2020) (Figure 1) due to its nutritional value. Due to the high concentration of omega-3 fatty acids, flaxseeds are becoming a popular addition to the vegetarian diets of many health-conscious consumers. Flaxseeds have a bright, smooth, and solid shell. The color of flax varies depending on whether it is of the brown or gold variety, from dark amber to rusty brown. About 15% of the mucilage in the embryo's testa or envelope is mucilage. Flaxseed is a rich source of fat, protein, and dietary fiber as mentioned in Table 1. The composition of flaxseed can vary depending on its genetics, the climate in which it develops, and the processing technique (Rodrigues *et*

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al., 2012). On average, brown Canadian flaxseed contains 41% fat, 20% protein, 28% total dietary fiber, 7.7% moisture, and 3.4% ash (Viveky *et al.*, 2015; Bhavana *et al.*, 2021)). As the concentration of fatty acids increases, the amino acid content of the seed decreases. The high concentration of unsaturated lipids in flaxseeds is now widely acknowledged (Aly-Aldin *et al.*, 2015). Due to its nutritional composition, which has positive effects on disease prevention by providing health-beneficial elements, linseed has become known as a functional food (Yasmeen *et al.*, 2018).



Figure 1. Flaxseed.

2. Compositions

Flaxseeds have a bright, smooth, and solid shell. The color of flax varies depending on whether it is of the brown or gold variety, from dark amber to rusty brown. About 15% of the mucilage in the embryo's testa or envelope is mucilage. Flaxseed is a rich source of fat, protein, and dietary fiber as mentioned in Table 1. The composition of flaxseed can vary depending on its genetics, the climate in which it develops, and the processing technique (Rodrigues *et al.*, 2012). On average, brown Canadian flaxseed contains 41% fat, 20% protein, 28% total dietary fiber, 7.7% moisture, and 3.4% ash (Viveky *et al.*, 2015; Bhavana *et al.*, 2021). As the concentration of fatty acids increases, the amino acid content of the seed decreases. The high concentration of unsaturated lipids in flaxseeds is now widely acknowledged (Aly-Aldin *et al.*, 2015). Due to its nutritional composition, which has positive effects on disease prevention by providing health-beneficial elements, linseed has become known as a functional food (Yasmeen *et al.*, 2018).

Table 1. Fatty acid of flaxseed.

Fatty Acid	g/100 g
Palmitic acid	2.1
Stearic acid	1.3
Oleic acid	7.3
Linolenic acid	5.9
α -linoenic acid	22.8

Source: Parikh *et al.* (2021).

2.1 Macronutrients in flaxseed

In the past, flaxseed was prized for its high-fat content, which provides a unique combination of fatty acids. Omega-3 fatty acid alpha-linoleniclinolenic acid is prevalent in flaxseed. Several chronic diseases, including type 2 diabetes, kidney failure, rheumatoid arthritis, high blood pressure, coronary heart disease, stroke, Alzheimer's disease, alcoholism, and certain types of cancer, can be prevented or managed with the aid of omega-3 fatty acids (Kim and Chung, 2011). Flaxseed oil contains significant levels of C18:3, n-3 alpha-linolenic acid, according to a Canadian Grain Board approximation (Okhti *et al.*, 2016). The lipid content was calculated using the Official Method Am 2-93 of the American Oil Chemists' Society (AOCS). 7.7% of the substance was damp. ALA, or alpha-linolenic acid, is an essential omega-3 fatty acid. The observation that omega-3 fatty acids have a cancer-inhibiting effect has led to the theory that flaxseed fatty acid cosmetics may render it tumor-protective (Rodriguez-Leyva *et al.*, 2013). As one of the most nutrient-dense plant proteins, legume protein is believed to have an amino acid composition most similar to flax protein. The quantities of amino acids in the proteins of the two flax cultivars. Flax contains no gluten. Gliadin, which is rich in amino acids such as proline and glutamine, is the gluten component responsible for the onset of "celiac disease" (Wu *et al.*, 2010; Lan *et al.*, 2020). Flaxseed is low in carbohydrates. Therefore, flax contributes a negligible quantity to the total amount of carbohydrates consumed. The chemical formula for carbohydrates is CHO. There are 1 g of total carbohydrates, including glucose and sugars, and 28 g of total dietary fiber per 100 g of flaxseeds (Chaudhary *et al.*, 2018; de la Bastida *et al.*, 2021).

2.2 Fiber content in flaxseed

The sum of dietary fiber and physiological fiber yields the total amount of energy. Functional energy is derived from the separation of nondigestible carbohydrates from plants. Since they are not digested and absorbed by the human small intestine (Khouryieh and Aramouni, 2012), functional or dietary fibers migrate into the large intestine relatively quietly. Approximately 28% of the weight of whole flaxseeds is comprised of total fiber. On the basis of solubility, there are primarily two types of fiber: soluble and insoluble. Flax contains both soluble and insoluble dietary fiber as mentioned in Table 2. Dietary fiber functions as a bulking agent in the intestine. It decreases the time required for food to travel through the colon while increasing stool weight and viscosity. In this way, dietary fiber promotes bowel movements, reduces blood lipids, and helps regulate appetite and blood sugar. High-fiber

diets may reduce the incidence of inflammation, diabetes, colon cancer, cardiovascular disease, and other

Table 2. Dietary fiber of flaxseed.

Dietary fibers	g/100 g
Soluble	4.3-8.6
Insoluble	12.8-17.1

Source: Parikh *et al.* (2021).

diseases (Man *et al.*, 2021).

2.3 Lignins

It is a densely branched fiber found in the cell walls of woody plants. Lignan is a substance with a similar name to lignins (Suri *et al.*, 2020). Both are associated with cell wall polysaccharides and constitute plant cell walls. Lignins contribute to the cell wall's strength and rigidity. Phytochemicals known as lignans are presently being studied for their potential role in human nutrition, particularly in hormone-related cancer, osteoporosis and cardiovascular diseases. In particular, flaxseeds are the richest dietary source of lignan precursors. When ingested, lignan precursors are converted to enterolignans, enterodiols and enterolactone, by bacteria that normally colonize the human intestine. The principal lignan precursor found in flaxseed is secoisolariciresinol diglucoside (Wu *et al.*, 2010; Prajapati *et al.*, 2016).

2.4 Phenolics

Phenolics are plant-derived organic compounds that serve a variety of functions, such as imparting color to plants and attracting bees and other pollinators (Zhang *et al.*, 2019). Multiple phenolic compounds appear to have antioxidant and cancer-fighting properties in humans (de la Bastida *et al.*, 2021). There are at least three different types of phenolics in flax (Amin and Thakur, 2014), including phenolic acids (approximately 1%) flavonoids (35-70 mg/100 g) and lignans in flax. Lignans range from 1 mg/g of seed to over 26 mg/g of seed (Wu *et al.*, 2010). Compared to other plant sources, flax contains 75 to 100 times more lignans. They are also considered phytoestrogens because they help the body regulate its own hormone levels, including estrogen. The most

abundant lignan in flaxseed is Secoisolariciresinol Diglucoside (SDG), a component of a linear ester-linked complex in which the C6-OH of the hyperglycemia in SDG is esterified to the carboxylic acid of hydroxymethyl glutaric acid.

2.5 Minerals and vitamins

Flaxseed contains numerous water- and fat-soluble vitamins (Dobrowolska and Regulska-Ilow, 2021), as detailed in Table 3. Vitamin E is abundant in flax, predominantly in the form of gamma-tocopherol. Gamma-tocopherol is an antioxidant that reduces the risk of cardiovascular disease, certain cancers, and Alzheimer's disease (Meagher *et al.*, 1999; Khare *et al.*, 2021). In addition, it prevents the oxidation of cell proteins and fats and promotes the excretion of sodium through the urine, which may assist in lowering blood pressure. The concentration of tocopherol in flax is affected by the variety, seed maturity, growing region, environmental variables, and extraction method. Levels of gamma-tocopherol can range from 0.7 to 3.2 mg per tablespoon of ground flax or from 8.5 to 39.5 mg per 100 g of seed (Suri *et al.*, 2020). Vitamin K is identified in plants as phyloquinone, which is present in flax in low concentrations. Vitamin K is essential for the formation of proteins involved in blood coagulation and bone growth (Herchi *et al.*, 2015). A 250 mL (8 oz) bottle of low-fat yogurt with fruit, 30 g (1 oz) of pecan halves, and half of a fried chicken breast (140 g) all contain the same quantity of magnesium per meal as one tablespoon of milled flaxseeds containing 34 mg of magnesium. A hard-boiled egg, a 175 mL (6 oz) mug of brewed tea, and a standard slice of pumpernickel bread all contain nearly the same quantity of oxygen per tablespoon as milled flax (66 mg) (Wu *et al.*, 2010; Dobrowolska and Regulska-Ilow, 2021). Flax has a lower sodium content. Phytic acid and oxalate, which are present in flaxseed, have the ability to form insoluble complexes with calcium, copper, iron, magnesium, and zinc. The study concluded that alpha-, delta-, and gamma-tocotrienol, as well as beta-tocopherol, do not qualify as vitamin E molecules (Ibrahim *et al.*, 2020). The flaxseeds are shown to possess a phytic acid content ranging from

Table 3. Minerals and vitamins in flaxseed.

Minerals	mg/100 g	Vitamins	mg/100 g
Calcium	236	γ -tocopherol	522
Magnesium	431	α -tocopherol	7
Phosphorous	622	Pantothenic acid	0.6
Sodium	4	Pyridoxine/vitamin B6	0.6
Zinc	1	Niacin/nicotinic acid	3.2
Copper	5	Riboflavin/vitamin B2	0.2
Iron	3	δ -tocopherol	10

Source: Parikh *et al.* (2021).

0.8% to 1.5%, alongside a minimal oxalate concentration of less than 10 mg per kilogram. Flaxseed, peanuts, and soybeans exhibit comparable levels of phytic acid content. Phytic acid is found in a wide variety of plant-based diets. Insufficient intake of phytate, calcium, and zinc by rats has been observed to result in stunted development and a decrease in zinc levels in their bones (Khalil *et al.*, 2021). In the case of rodents, existing research suggests that phytic acid has the potential to lower blood glucose levels and mitigate the likelihood of developing gastrointestinal cancer (Zhuang *et al.*, 2021).

3. Benefits of flaxseed

One serving of flaxseed provides a good amount of protein, fiber, and omega-3 fatty acids. It may help lower the risk of some cancers, help maintain a healthy weight, and reduce cholesterol and blood pressure and other health conditions as mentioned in Figure 2 and Table 4. In India, flaxseed has a lengthy history of use, and its medicinal qualities and nutritional value are highly valued (Eliasson *et al.*, 2003; Noreen Tufail *et al.*, 2023a). As flaxseed chutney, flaxseed is consumed to a reduced extent in Southern India. *Linum usitatissimum* L, the plant that produces linseed, is a member of the Linoceae family. Secoisolariciresinol diglucoside, a precursor to mammalian lignans, is 75-800 times more concentrated in flaxseed than in other plants (Khalil *et al.*, 2021). Initial laboratory investigations on the lipid-lowering and liver-protective effects of linseed chutney in rats were promising (Mohamed *et al.*, 2020). It has been shown that whole flaxseeds reduce levels of total and LDL cholesterol, nocturnal glucose absorption, and certain inflammatory markers, and increase blood levels of omega-3 fatty acids. Since defatted flaxseeds have the

same cholesterol-lowering effect as whole flaxseeds, the lignans and/or fiber in flaxseeds are responsible for their cholesterol-lowering properties. The two primary nutrients of flax, ALA and SDG, are resistant to roasting temperatures.

According to one study, heating whole or pulverized flax at temperatures as high as 350°C for 60 mins had little effect on the fatty acid content or oxidation and did not result in the formation of new trans forms of ALA or other undesirable fatty acid byproducts. In addition to providing nutritional benefits, the gluten-free protein and fiber content of flaxseed also possesses antioxidant, anticancer, and antibacterial properties (Khalil *et al.*, 2021). Humans can tolerate and derive nutritional benefits from up to 50 g of high-alpha-linolenic-acid flaxseed per day by increasing levels of n-3 fatty acids in plasma and erythrocytes and decreasing postprandial blood glucose responses. After four weeks of daily flaxseed consumption, alpha linolenate and n-3 polyunsaturates were detected in adipose tissue. In



Figure 2. Health benefits of flaxseed.

Table 4. Health benefits of flaxseed.

Biological Properties	Explanation	References
Anti-cancer	Reduce colon and breast cancer incidence and early risk factors.	Hanaa <i>et al.</i> (2017)
	Lignans may protect against certain cancers, particularly hormone-sensitive cancers such as those of the breast, endometrium and prostate, by interfering with sex hormone metabolism. Flaxseed lignans and their metabolites possess anticancer properties.	Mueed <i>et al.</i> (2022)
Antidiabetic	Flaxseeds play a role in treating diabetes type 2 as they decrease the fasting plasma glucose (FPG) concentrations in pre-diabetes. According to a study, when 13 g/day flaxseeds in low-dose treatment are given, it reduces the fasting plasma glucose.	Hutchins <i>et al.</i> (2013)
Antioxidant	The antioxidant activity of flaxseed is shown to reduce total cholesterol and platelet aggregation.	Naik <i>et al.</i> (2018)
	Antioxidant properties of flaxseed lignan secoisolariciresinol diglucoside SDG are responsible for its hypoglycemic effects in type-2 diabetes.	Tenda and Toyo (2021)
Anti-inflammatory	Among components of flaxseeds, long-chain ω -3 fatty acids are especially acknowledged for their anti-inflammatory effects. Flaxseed and its derivatives are beneficial for human health, possibly because of their anti-inflammatory effects. C-reactive protein (CRP), a sensitive marker of inflammation was chosen to evaluate the anti-inflammatory effects of flaxseed.	de Abreu Maíra <i>et al.</i> (2018)

conjunction with a 30% weekly increase in gastrointestinal movements, total urinary lignan excretion increased by more than fivefold, and plasma cholesterol decreased by up to 8% (Khalil *et al.*, 2021). According to a comparison of ALA's biological effects with those of long-chain omega-3 derivatives, ALA does not possess the same biological effects as the long-chain omega-3 fatty acids found in marine fish oils. When ALA is metabolized, eicosapentaenoic acid may assume the role of arachidonic acid in membrane phospholipids. Consumption of flaxseed oil may have anti-allergic, anti-atherosclerotic, and antiarrhythmic effects. It may also alter the production of eicosanoids, the effectiveness of blood clots, and other membrane-dependent responses. It has been shown that flaxseed oil has beneficial effects on the management and prevention of cardiovascular disease. Significant quantities of 2 cinnamic acid glycoside have also been identified in flaxseed and lignan extracts. According to a number of investigations, the conversion of flaxseed into the mammalian lignans enterolactone (EL) and enterodiols (ED) is responsible for their biological activity (Chen *et al.*, 2022). Flaxseed contains a higher concentration of the plant precursor secoisolariciresinol diglucoside, which is used by microorganisms in the colon to produce mammalian lignans enterolactone and enterodiol (Stewart *et al.*, 2020).

According to studies on the bioavailability of ALA, only milled flaxseed and flax oil significantly increased plasma levels of ALA, while whole flaxseed did not. Several participants experienced negative gastrointestinal effects within four weeks after consuming whole seed and oil preparations. The milled form of flaxseed may be an excellent option for human consumption if you wish to avoid negative side effects while giving your body a substantial ALA boost (Wang and Bao, 2019). In individuals with hyperlipidemia, ground flaxseed reduced Lp (a), increased insulin sensitivity, and had a small but transient effect on LDL-C. The effect of flaxseed on diminishing HDL-C in men. Only a few flax-related allergic reactions have been reported in the medical literature, indicating that flax food allergy is relatively uncommon (Noreen *et al.*, 2023b). Plants contain cyanogenic glycosides, a class of chemical compounds that, when broken down by enzymes or organic acids, emit cyanide. In multiple clinical studies, volunteers ingested muffins containing 50 g (5-6 tbsp) of milled flax daily for up to 6 weeks without experiencing adverse effects. The absence of cyanogenic glycosides in ground flax indicates that heating destroys the enzyme responsible for glycoside metabolism (Naik *et al.*, 2018).

3.1 Diabetes-combating properties of flaxseed

Daily lignan supplementation improved glycemic control in patients with type 2 diabetes very marginally, but statistically significantly, without affecting fasting glucose levels, lipid profiles, or insulin sensitivity (Özbiçer *et al.*, 2022). Ingestion of flaxseed fiber decreased peak blood glucose levels in type II diabetic patients as mentioned in Figure 3. The poorest of the impoverished who suffer from diabetes in rural areas can use flax cake as a supplement after the oil has been extracted. In Zucker diabetic fatty/Gmi-fa/fa female rats, it has been discovered that flaxseed-extracted SDG delays the advent of diabetes (Tufail *et al.*, 2021). Lignin from flaxseed, SDG improved hyperlipidaemia, hypercholesterolaemia, hyperinsulinemia, and hyperleptinemia; decreased visceral and hepatic fat accumulation resulting from high-fat diets. These effects may reduce the risk of cardiovascular disease associated with lifestyle disorders such as diabetes, atherosclerosis, and hypertension, and help prevent obesity. In addition to containing PUFA and dietary fiber, flaxseeds are a

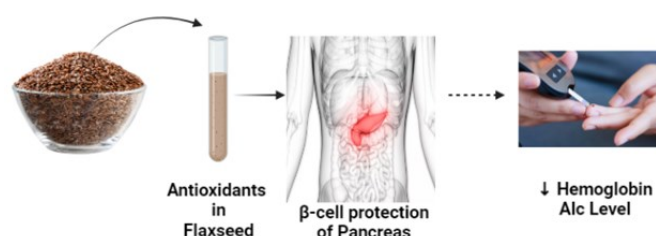


Figure 3. Effect of flaxseed on the pancreas.

promising food for lowering the risk of lifestyle-related disorders (Kim *et al.*, 2022).

3.2 Anti-oxidative actions of flaxseed

The antioxidant activity of flaxseed has been shown to reduce total cholesterol and platelet aggregation (Naik *et al.*, 2018). In the past, it has been demonstrated that the mammalian lignans ED and EL, as well as the flaxseed lignan secoisolariciresinol diglucoside (SDG), are all effective antioxidants against DNA damage and lipid peroxidation. At supraphysiological concentrations, Secoisolariciresinol (SECO) inhibits the chemiluminescence of active cells. Also evaluated were EL and ED. It was believed that the 3-methoxy-4-hydroxy substituents of SDG and SECO were responsible for the antioxidant properties of lignan (Aly-Aldin *et al.*, 2015). The flaxseed compound secoisolariciresinol diglucoside has been shown to be effective in deferring or preventing the onset of type-1 and type-2 diabetes. It has been suggested that the antioxidant properties of SDG are responsible for its hypoglycemic effects in type-2 diabetes. phosphoenolpyruvate carboxykinase, a rate-limiting enzyme in the gluconeogenesis pathway, may be responsible for the hypoglycemic effect of SDG in type-

2 diabetes (Tenda and Toyo, 2021). Lower levels of lipid peroxidation (TBARS) and the predictive enzyme - glutamyl transpeptidase were evidence of the flaxseed chutney's antioxidant properties in rodents treated with

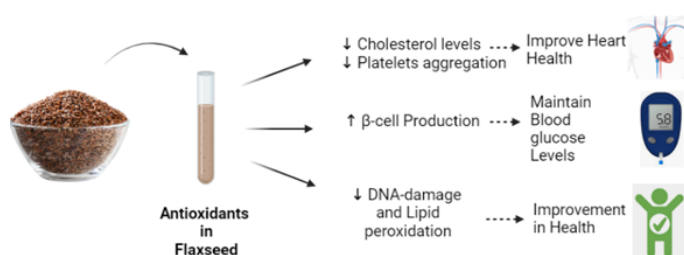


Figure 4. Anti-oxidative actions of flaxseed.

azoxymethane. Antioxidants play an important role in our health as mentioned in Figure 4.

3.3 Anti-inflammation properties of flaxseed

After receiving lignan capsules (360 mg/d) for 12 weeks, diabetic participants with mild hypercholesterolemia had substantially reduced C-reactive protein levels (Sharma and Saini, 2022). Flaxseed lignans are converted by intestinal microorganisms into the so-called entero lignans enterodiol and enterolactone. Little information is available on the bioavailability of entero-lignans; however, the relative bioavailability of enterolignans in whole flaxseed was 28% greater than that of powdered flaxseed ($p < 0.05$), thereby reducing relative coronary disease risk factors. Models of lupus and polycystic kidney disease have demonstrated the beneficial effects of flaxseed or SDG. It has also been reported that flaxseed has hepatoprotective properties. Mechanistically, the reported bioactivities can be explained in a number of ways, including participation in hormone availability or metabolism, angiogenesis, antioxidation, and gene repression (Ume Salma *et al.*, 2019).

3.4 Anti-cancer properties of flaxseed

Although there are some studies with either inconclusive or unfavorable results, the majority of studies on the effects of lignans on breast, colon, prostate, and thyroid cancer have demonstrated favorable outcomes. In animal models, flaxseed has been found to reduce colon and breast cancer incidence and early risk factors (Hanaa *et al.*, 2017). Flaxseed lignans have been shown to reduce mammary tumor size by more than 50% and tumor number by 37% in rats subjected to carcinogens (Ji *et al.*, 2019). Influence of flaxseed consumption on cancer risk indicators Epidemiologic studies have also demonstrated that vegetarian diets reduce the incidence of breast cancer (Barthet *et al.*, 2014) and that lignin concentrations in omnivores and

breast cancer patients are significantly lower. Consequently, it is becoming increasingly evident that lignans possess a variety of advantageous properties. Both dietary fiber and phytoestrogen have been found to have anti-cancer properties. The markedly increased lignan excretion in the urine of premenopausal women after consuming flaxseeds (Hussein *et al.*, 2014) suggests that the chemoprotective effects of flaxseed may have been mediated by mechanisms other than a hormonal effect. It has been discovered that flaxseed consumption has significant antiatherogenic effects. The anti-atherogenic effect of flaxseeds was demonstrated when 10% flaxseed was added to the diets of LDL receptor-deficient (Hussein *et al.*, 2014). This resulted in a reduction of cholesterol levels in the bloodstream.

3.5 Nephrological properties of flaxseed

In animal models of renal injury, such as Han: SP RD-cy Polycystic Kidney Disease (PKD), flaxseed derivatives, including oil and flax lignans, modulate the progression of renal injury (Podstawczyk *et al.*, 2015). Male obese SHR/N-cp rats were randomly assigned to one of three diets consisting of 20% casein, 20% soy protein concentrate, or 20% flaxseed meal. Except for the protein source, all three diets had comparable quantities of protein, fat, carbs, minerals, and vitamins. All animals were fed these foods for a period of six months. All three groups exhibited hyperglycemia and hyperinsulinemia during fasting, along with comparable rates of food consumption and weight gain (Park *et al.*, 1999). Although there was no difference in plasma glucose levels between the three groups, the plasma insulin levels of rats fed flaxseed meal were significantly lower than those fed casein or soy protein concentrate. In addition, there were no discernible differences between the three groups in terms of mean plasma creatinine, creatinine clearance, or urine urea excretion. In contrast, rats fed flaxseed excreted significantly less protein in their urine ($P < 0.01$) than rats fed casein or soy protein concentrate. reducing proteinuria and kidney histologic abnormalities in this model. Proteinuria and renal impairment were reduced independently of protein consumption and glycemic management. It is unknown at this time which dietary component(s) of flaxseed meal are responsible for the renal protective effect (Navaie *et al.*, 2018).

3.6 Flaxseed for healthy bones

When individuals ingest foods rich in omega-3 fats, the ratio of omega-6 to omega-3 fats in their diet decreases, preventing excessive bone turnover and promoting bone health (de Abreu Maira *et al.*, 2018). When given 2 tablespoons of crushed flaxseed twice a day for six weeks, women who were experiencing 14 or

more hot flashes per week and were not using oestrogen to manage their menopausal symptoms saw a reduction of 50% in their daily hot flashes. In addition, the intensity of the women's hot flushes decreased by 57%. Side effects included abdominal bloating (14 women) and mild diarrhea (8 women) (da Costa *et al.*, 2016).

4. Conclusion

Functional foods and nutraceuticals may reduce the healthcare system's burden through continuous prevention. Continuous prevention with functional meals and nutraceuticals may lower healthcare costs. Many industrialized and developing nations employ plant-based meals in primary healthcare. Plant-based diets contain phytochemicals and bioactive substances. Functional foods and healthy diets should consider the synergistic effects of a mixture of bioactive in-source materials and complementary phytochemicals from different sources. Nutraceuticals and functional foods increase health and happiness. Thirty years of research have shown flaxseed's nutritional benefits. Processing innovations allow health-conscious consumers to find flaxseed in numerous nutritious forms. Traditional medicine and diet use flaxseed ligands. Flaxseed secoisolariciresinol diglucoside enabled studying SDG and its metabolites' anti-tumor properties easily. Enterolactone and enterodiol inhibit cell proliferation and early breast and colon cancer risk indicators in animals. ALA, fiber, and lignans make flaxseed a promising cardiovascular health food. Flax, the richest source of ALA and soluble fiber, increases blood eicosapentaenoic acid and ALA, lowers total and LDL cholesterol, and reduces postprandial glucose absorption. How this functional diet reduces cancer and cardiovascular risks needs further study. Studying how flaxseed components affect lifestyle diseases and cancer cellular pathways is crucial.

Conflict of interest

The authors declare no conflict of interest.

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